Biology

Subject: Science
Grade: 09
Expectations: 45
Breakouts: 191

(a) Introduction.

1. Biology. Students in Biology focus on patterns, processes, and relationships of living organisms through four main concepts: biological structures, functions, and processes; mechanisms of genetics; biological evolution; and interdependence within environmental systems. By the end of Grade 12, students are expected to gain sufficient knowledge of the scientific and engineering practices across the disciplines of science to make informed decisions using critical thinking and scientific problem solving.

2. Nature of science. Science, as defined by the National Academy of Sciences, is the "use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process." This vast body of changing and increasing knowledge is described by physical, mathematical, and conceptual models. Students should know that some questions are outside the realm of science because they deal with phenomena that are not currently scientifically testable.

3. Scientific hypotheses and theories. Students are expected to know that:

    a. hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence. Hypotheses of durable explanatory power that have been tested over a wide variety of conditions are incorporated into theories; and

    b. scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well established and highly reliable explanations, but they may be subject to change as new areas of science and new technologies are developed.

4. Scientific inquiry. Scientific inquiry is the planned and deliberate investigation of the natural world using scientific and engineering practices. Scientific methods of investigation are descriptive, comparative, or experimental. The method chosen should be appropriate to the question being asked. Student learning for different types of investigations include descriptive investigations, which involve collecting data and recording observations without making comparisons; comparative investigations, which involve collecting data with variables that are manipulated to compare results; and experimental investigations, which involve processes similar to comparative investigations but in which a control is identified.

    a. Scientific practices. Students should be able to ask questions, plan and conduct investigations to answer questions, and explain phenomena using appropriate tools and models.

    b. Engineering practices. Students should be able to identify problems and design solutions using appropriate tools and models.

5. Science and social ethics. Scientific decision making is a way of answering questions about the natural world involving its own set of ethical standards about how the process of science should be carried out. Students should be able to distinguish between scientific decision-making methods (scientific methods) and ethical and social decisions that involve science (the application of scientific information).

6. Science consists of recurring themes and making connections between overarching concepts. Recurring themes include systems, models, and patterns. All systems have basic properties that can be described in space, time, energy, and matter. Change and constancy occur in systems as patterns and can be observed, measured, and modeled. These patterns help to make predictions that can be scientifically tested, while models allow for boundary specification and provide a tool for understanding the ideas presented. Students should analyze a system in terms of its components and how these components relate to each other, to the whole, and to the external environment.

7. Statements containing the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.

(b) Knowledge and Skills Statements

(1) Scientific and engineering practices. The student, for at least 40% of instructional time, asks questions, identifies problems, and plans and safely conducts classroom, laboratory, and field investigations to answer questions, explain phenomena, or design solutions using appropriate tools and models. The student is expected to:

(A) ask questions and define problems based on observations or information from text, phenomena, models, or investigations;

(i) ask questions based on observations or information from text, phenomena, models, or investigations

(ii) define problems based on observations or information from text, phenomena, models, or investigations

(B) apply scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems;

(i) apply scientific practices to plan descriptive investigations

(ii) apply scientific practices to plan comparative investigations

(iii) apply scientific practices to plan experimental investigations

(iv) apply scientific practices to conduct descriptive investigations

(v) apply scientific practices to conduct comparative investigations

(vi) apply scientific practices to conduct experimental investigations

(vii) use engineering practices to design solutions to problems

(C) use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards;

(i) use appropriate safety equipment during laboratory investigations as outlined in Texas Education Agency-approved safety standards

(ii) use appropriate safety equipment during classroom investigations as outlined in Texas Education Agency-approved safety standards

(iii) use appropriate safety equipment during field investigations as outlined in Texas Education Agency-approved safety standards

(iv) use appropriate safety practices during laboratory investigations as outlined in Texas Education Agency-approved safety standards

(v) use appropriate safety practices during classroom investigations as outlined in Texas Education Agency-approved safety standards

(vi) use appropriate safety practices during field investigations as outlined in Texas Education Agency-approved safety standards

(D) use appropriate tools such as microscopes, slides, Petri dishes, laboratory glassware, metric rulers, digital balances, pipets, filter paper, micropipettes, gel electrophoresis and polymerase chain reaction (PCR) apparatuses, microcentrifuges, water baths, incubators, thermometers, hot plates, data collection probes, test tube holders, lab notebooks or journals, hand lenses, and models, diagrams, or samples of biological specimens or structures;

(i) use appropriate tools

(E) collect quantitative data using the International System of Units (SI) and qualitative data as evidence;

(i) collect quantitative data using the International System of Units (SI)

(ii) collect qualitative data as evidence

(F) organize quantitative and qualitative data using scatter plots, line graphs, bar graphs, charts, data tables, digital tools, diagrams, scientific drawings, and student-prepared models;

(i) organize quantitative data using scatter plots

(ii) organize quantitative data using line graphs

(iii) organize quantitative data using bar graphs

(iv) organize quantitative data using charts

(v) organize quantitative data using data tables

(vi) organize quantitative data using digital tools

(vii) organize quantitative data using diagrams

(viii) organize quantitative data using scientific drawings

(ix) organize quantitative data using student-prepared models

(x) organize qualitative data using charts

(xi) organize qualitative data using data tables

(xii) organize qualitative data using digital tools

(xiii) organize qualitative data using diagrams

(xiv) organize qualitative data using scientific drawings

(xv) organize qualitative data using student-prepared models

(G) develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and

(i) develop models to represent phenomena, systems, processes, or solutions to engineering problems

(ii) use models to represent phenomena, systems, processes, or solutions to engineering problems

(H) distinguish among scientific hypotheses, theories, and laws.

(i) distinguish among scientific hypotheses, theories, and laws

(2) Scientific and engineering practices. The student analyzes and interprets data to derive meaning, identify features and patterns, and discover relationships or correlations to develop evidence-based arguments or evaluate designs. The student is expected to:

(A) identify advantages and limitations of models such as their size, scale, properties, and materials;

(i) identify advantages of models

(ii) identify limitations of models

(B) analyze data by identifying significant statistical features, patterns, sources of error, and limitations;

(i) analyze data by identifying significant statistical features

(ii) analyze data by identifying patterns

(iii) analyze data by identifying sources of error

(iv) analyze data by identifying limitations

(C) use mathematical calculations to assess quantitative relationships in data; and

(i) use mathematical calculations to assess quantitative relationships in data

(D) evaluate experimental and engineering designs.

(i) evaluate experimental designs

(ii) evaluate engineering designs

(3) Scientific and engineering practices. The student develops evidence-based explanations and communicates findings, conclusions, and proposed solutions. The student is expected to:

(A) develop explanations and propose solutions supported by data and models and consistent with scientific ideas, principles, and theories;

(i) develop explanations supported by data and consistent with scientific ideas

(ii) develop explanations supported by data and consistent with scientific principles

(iii) develop explanations supported by data and consistent with scientific theories

(iv) develop explanations supported by models and consistent with scientific ideas

(v) develop explanations supported by models and consistent with scientific principles

(vi) develop explanations supported by models and consistent with scientific theories

(vii) propose solutions supported by data and consistent with scientific ideas

(viii) propose solutions supported by data and consistent with scientific principles

(ix) propose solutions supported by data and consistent with scientific theories

(x) propose solutions supported by models and consistent with scientific ideas

(xi) propose solutions supported by models and consistent with scientific principles

(xii) propose solutions supported by models and consistent with scientific theories

(B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and

(i) communicate explanations individually in a variety of settings

(ii) communicate explanations individually in a variety of formats

(iii) communicate explanations collaboratively in a variety of settings

(iv) communicate explanations collaboratively in a variety of formats

(v) communicate solutions individually in a variety of settings

(vi) communicate solutions individually in a variety of formats

(vii) communicate solutions collaboratively in a variety of settings

(viii) communicate solutions collaboratively in a variety of formats

(C) engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence.

(i) engage respectfully in scientific argumentation using applied scientific explanations

(ii) engage respectfully in scientific argumentation using empirical evidence

(4) Scientific and engineering practices. The student knows the contributions of scientists and recognizes the importance of scientific research and innovation on society. The student is expected to:

(A) analyze, evaluate, and critique scientific explanations and solutions by using empirical evidence, logical reasoning, and experimental and observational testing, so as to encourage critical thinking by the student;

(i) analyze scientific explanations and solutions by using empirical evidence so as to encourage critical thinking by the student

(ii) analyze scientific explanations and solutions by using logical reasoning so as to encourage critical thinking by the student

(iii) analyze scientific explanations and solutions by using experimental testing so as to encourage critical thinking by the student

(iv) analyze scientific explanations and solutions by using observational testing so as to encourage critical thinking by the student

(v) evaluate scientific explanations and solutions by using empirical evidence so as to encourage critical thinking by the student

(vi) evaluate scientific explanations and solutions by using logical reasoning so as to encourage critical thinking by the student

(vii) evaluate scientific explanations and solutions by using experimental testing so as to encourage critical thinking by the student

(viii) evaluate scientific explanations and solutions by using observational testing so as to encourage critical thinking by the student

(ix) critique scientific explanations and solutions by using empirical evidence so as to encourage critical thinking by the student

(x) critique scientific explanations and solutions by using logical reasoning so as to encourage critical thinking by the student

(xi) critique scientific explanations and solutions by using experimental testing so as to encourage critical thinking by the student

(xii) critique scientific explanations and solutions by using observational testing so as to encourage critical thinking by the student

(B) relate the impact of past and current research on scientific thought and society, including research methodology, cost-benefit analysis, and contributions of diverse scientists as related to the content; and

(i) relate the impact of past research on scientific thought, including research methodology

(ii) relate the impact of past research on scientific thought, including cost-benefit analysis

(iii) relate the impact of past research on scientific thought, including contributions of diverse scientists as related to the content

(iv) relate the impact of past research on society, including research methodology

(v) relate the impact of past research on society, including cost-benefit analysis

(vi) relate the impact of past research on society, including contributions of diverse scientists as related to the content

(vii) relate the impact of current research on scientific thought, including research methodology

(viii) relate the impact of current research on scientific thought, including cost-benefit analysis

(ix) relate the impact of current research on scientific thought, including contributions of diverse scientists as related to the content

(x) relate the impact of current research on society, including research methodology

(xi) relate the impact of current research on society, including cost-benefit analysis

(xii) relate the impact of current research on society, including contributions of diverse scientists as related to the content

(C) research and explore resources such as museums, libraries, professional organizations, private companies, online platforms, and mentors employed in a science, technology, engineering, and mathematics (STEM) field in order to investigate STEM careers.

(i) research STEM careers

(ii) explore resources in order to investigate STEM careers

(5) Science concepts--biological structures, functions, and processes. The student knows that biological structures at multiple levels of organization perform specific functions and processes that affect life. The student is expected to:

(A) relate the functions of different types of biomolecules, including carbohydrates, lipids, proteins, and nucleic acids, to the structure and function of a cell;

(i) relate the functions of different types of biomolecules, including carbohydrates, to the structure of a cell

(ii) relate the functions of different types of biomolecules, including lipids, to the structure of a cell

(iii) relate the functions of different types of biomolecules, including proteins, to the structure of a cell

(iv) relate the functions of different types of biomolecules, including nucleic acids, to the structure of a cell

(v) relate the functions of different types of biomolecules, including carbohydrates, to the function of a cell

(vi) relate the functions of different types of biomolecules, including lipids, to the function of a cell

(vii) relate the functions of different types of biomolecules, including proteins, to the function of a cell

(viii) relate the functions of different types of biomolecules, including nucleic acids, to the function of a cell

(B) compare and contrast prokaryotic and eukaryotic cells, including their complexity, and compare and contrast scientific explanations for cellular complexity;

(i) compare prokaryotic and eukaryotic cells, including their complexity

(ii) contrast prokaryotic and eukaryotic cells, including their complexity

(iii) compare and contrast scientific explanations for cellular complexity

(C) investigate homeostasis through the cellular transport of molecules; and

(i) investigate homeostasis through the cellular transport of molecules

(D) compare the structures of viruses to cells and explain how viruses spread and cause disease.

(i) compare the structures of viruses to cells

(ii) explain how viruses spread disease

(iii) explain how viruses cause disease

(6) Science concepts--biological structures, functions, and processes. The student knows how an organism grows and the importance of cell differentiation. The student is expected to:

(A) explain the importance of the cell cycle to the growth of organisms, including an overview of the stages of the cell cycle and deoxyribonucleic acid (DNA) replication models;

(i) explain the importance of the cell cycle to the growth of organisms, including an overview of the stages of the cell cycle

(ii) explain the importance of the cell cycle to the growth of organisms, including deoxyribonucleic acid (DNA) replication models

(B) explain the process of cell specialization through cell differentiation, including the role of environmental factors; and

(i) explain the process of cell specialization through cell differentiation, including the role of environmental factors

(C) relate disruptions of the cell cycle to how they lead to the development of diseases such as cancer.

(i) relate disruptions of the cell cycle to how they lead to the development of diseases

(7) Science concepts--mechanisms of genetics. The student knows the role of nucleic acids in gene expression. The student is expected to:

(A) identify components of DNA, explain how the nucleotide sequence specifies some traits of an organism, and examine scientific explanations for the origin of DNA;

(i) identify components of DNA

(ii) explain how the nucleotide sequence specifies some traits of an organism

(iii) examine scientific explanations for the origin of DNA

(B) describe the significance of gene expression and explain the process of protein synthesis using models of DNA and ribonucleic acid (RNA);

(i) describe the significance of gene expression

(ii) explain the process of protein synthesis using models of DNA

(iii) explain the process of protein synthesis using models of ribonucleic acid (RNA)

(C) identify and illustrate changes in DNA and evaluate the significance of these changes; and

(i) identify changes in DNA

(ii) illustrate changes in DNA

(iii) evaluate the significance of changes [in DNA]

(D) discuss the importance of molecular technologies such as polymerase chain reaction (PCR), gel electrophoresis, and genetic engineering that are applicable in current research and engineering practices.

(i) discuss the importance of molecular technologies that are applicable in current research

(ii) discuss the importance of molecular technologies that are applicable in current engineering practices

(8) Science concepts--mechanisms of genetics. The student knows the role of nucleic acids and the principles of inheritance and variation of traits in Mendelian and non-Mendelian genetics. The student is expected to:

(A) analyze the significance of chromosome reduction, independent assortment, and crossing-over during meiosis in increasing diversity in populations of organisms that reproduce sexually; and

(i) analyze the significance of chromosome reduction in increasing diversity in populations of organisms that reproduce sexually

(ii) analyze the significance of independent assortment in populations of organisms that reproduce sexually

(iii) analyze the significance of crossing-over during meiosis in increasing diversity in populations of organisms that reproduce sexually

(B) predict possible outcomes of various genetic combinations using monohybrid and dihybrid crosses, including non-Mendelian traits of incomplete dominance, codominance, sex-linked traits, and multiple alleles.

(i) predict possible outcomes of various genetic combinations using monohybrid crosses, including non-Mendelian traits of incomplete dominance

(ii) predict possible outcomes of various genetic combinations using monohybrid crosses, including non-Mendelian traits of codominance

(iii) predict possible outcomes of various genetic combinations using monohybrid crosses, including non-Mendelian traits of sex-linked traits

(iv) predict possible outcomes of various genetic combinations using monohybrid crosses, including non-Mendelian traits of multiple alleles

(v) predict possible outcomes of various genetic combinations using dihybrid crosses

(9) Science concepts--biological evolution. The student knows evolutionary theory is a scientific explanation for the unity and diversity of life that has multiple lines of evidence. The student is expected to:

(A) analyze and evaluate how evidence of common ancestry among groups is provided by the fossil record, biogeography, and homologies, including anatomical, molecular, and developmental; and

(i) analyze how evidence of common ancestry among groups is provided by the fossil record

(ii) analyze how evidence of common ancestry among groups is provided by biogeography

(iii) analyze how evidence of common ancestry among groups is provided by homologies, including anatomical

(iv) analyze how evidence of common ancestry among groups is provided by homologies, including molecular

(v) analyze how evidence of common ancestry among groups is provided by homologies, including developmental

(vi) evaluate how evidence of common ancestry among groups is provided by the fossil record

(vii) evaluate how evidence of common ancestry among groups is provided by biogeography

(viii) evaluate how evidence of common ancestry among groups is provided by homologies, including anatomical

(ix) evaluate how evidence of common ancestry among groups is provided by homologies, including molecular

(x) evaluate how evidence of common ancestry among groups is provided by homologies, including developmental

(B) examine scientific explanations for varying rates of change such as gradualism, abrupt appearance, and stasis in the fossil record.

(i) examine scientific explanations for varying rates of change

(10) Science concepts--biological evolution. The student knows evolutionary theory is a scientific explanation for the unity and diversity of life that has multiple mechanisms. The student is expected to:

(A) analyze and evaluate how natural selection produces change in populations and not in individuals;

(i) analyze how natural selection produces change in populations and not in individuals

(ii) evaluate how natural selection produces change in populations and not in individuals

(B) analyze and evaluate how the elements of natural selection, including inherited variation, the potential of a population to produce more offspring than can survive, and a finite supply of environmental resources, result in differential reproductive success;

(i) analyze how the elements of natural selection, including inherited variation, result in differential reproductive success

(ii) analyze how the elements of natural selection, including the potential of a population to produce more offspring than can survive, result in differential reproductive success

(iii) analyze how the elements of natural selection, including a finite supply of environmental resources, result in differential reproductive success

(iv) evaluate how the elements of natural selection, including inherited variation, result in differential reproductive success

(v) evaluate how the elements of natural selection, including the potential of a population to produce more offspring than can survive, result in differential reproductive success

(vi) evaluate how the elements of natural selection, including a finite supply of environmental resources, result in differential reproductive success

(C) analyze and evaluate how natural selection may lead to speciation; and

(i) analyze how natural selection may lead to speciation

(ii) evaluate how natural selection may lead to speciation

(D) analyze evolutionary mechanisms other than natural selection, including genetic drift, gene flow, mutation, and genetic recombination, and their effect on the gene pool of a population.

(i) analyze evolutionary mechanisms other than natural selection, including genetic drift

(ii) analyze evolutionary mechanisms other than natural selection, including gene flow

(iii) analyze evolutionary mechanisms other than natural selection, including mutation

(iv) analyze evolutionary mechanisms other than natural selection, including genetic recombination

(v) analyze [genetic drift's] effect on the gene pool of a population

(vi) analyze [gene flow's] effect on the gene pool of a population

(vii) analyze [mutation's] effect on the gene pool of a population

(viii) analyze [genetic recombination's] effect on the gene pool of a population

(11) Science concepts--biological structures, functions, and processes. The student knows the significance of matter cycling, energy flow, and enzymes in living organisms. The student is expected to:

(A) explain how matter is conserved and energy is transferred during photosynthesis and cellular respiration using models, including the chemical equations for these processes; and

(i) explain how matter is conserved during photosynthesis using models, including the chemical equations for these processes

(ii) explain how matter is conserved during cellular respiration using models, including the chemical equations for these processes

(iii) explain how energy is transferred during photosynthesis using models, including the chemical equations for these processes

(iv) explain how energy is transferred during cellular respiration using models, including the chemical equations for these processes

(B) investigate and explain the role of enzymes in facilitating cellular processes.

(i) investigate the role of enzymes in facilitating cellular processes

(ii) explain the role of enzymes in facilitating cellular processes

(12) Science concepts--biological structures, functions, and processes. The student knows that multicellular organisms are composed of multiple systems that interact to perform complex functions. The student is expected to:

(A) analyze the interactions that occur among systems that perform the functions of regulation, nutrient absorption, reproduction, and defense from injury or illness in animals; and

(i) analyze the interactions that occur among systems that perform the [function] of regulation

(ii) analyze the interactions that occur among systems that perform the [function] of nutrient absorption

(iii) analyze the interactions that occur among systems that perform the [function] of reproduction

(iv) analyze the interactions that occur among systems that perform the [function] of defense from injury or illness in animals

(B) explain how the interactions that occur among systems that perform functions of transport, reproduction, and response in plants are facilitated by their structures.

(i) explain how the interactions that occur among systems that perform [function] of transport [is] facilitated by their structures

(ii) explain how the interactions that occur among systems that perform [function] of reproduction [is] facilitated by their structures

(iii) explain how the interactions that occur among systems that perform [function] of response in plants [is] facilitated by their structures

(13) Science concepts--interdependence within environmental systems. The student knows that interactions at various levels of organization occur within an ecosystem to maintain stability. The student is expected to:

(A) investigate and evaluate how ecological relationships, including predation, parasitism, commensalism, mutualism, and competition, influence ecosystem stability;

(i) investigate how ecological relationships, including predation, influence ecosystem stability

(ii) investigate how ecological relationships, including parasitism, influence ecosystem stability

(iii) investigate how ecological relationships, including commensalism, influence ecosystem stability

(iv) investigate how ecological relationships, including mutualism, influence ecosystem stability

(v) investigate how ecological relationships, including competition, influence ecosystem stability

(vi) evaluate how ecological relationships, including predation, influence ecosystem stability

(vii) evaluate how ecological relationships, including parasitism, influence ecosystem stability

(viii) evaluate how ecological relationships, including commensalism, influence ecosystem stability

(ix) evaluate how ecological relationships, including mutualism, influence ecosystem stability

(x) evaluate how ecological relationships, including competition, influence ecosystem stability

(B) analyze how ecosystem stability is affected by disruptions to the cycling of matter and flow of energy through trophic levels using models;

(i) analyze how ecosystem stability is affected by disruptions to the cycling of matter using models

(ii) analyze how ecosystem stability is affected by disruptions to the flow of energy through trophic levels using models

(C) explain the significance of the carbon and nitrogen cycles to ecosystem stability and analyze the consequences of disrupting these cycles; and

(i) explain the significance of the carbon cycle to ecosystem stability

(ii) explain the significance of the nitrogen cycle to ecosystem stability

(iii) analyze the consequences of disrupting [the carbon cycle]

(iv) analyze the consequences of disrupting [the nitrogen cycle]

(D) explain how environmental change, including change due to human activity, affects biodiversity and analyze how changes in biodiversity impact ecosystem stability.

(i) explain how environmental change, including change due to human activity, affects biodiversity

(ii) analyze how changes in biodiversity impact ecosystem stability